CME

Acid-Base Interpretation: A Practical Approach

Masahiro J. Morikawa, MD, MPH, and Prakash R. Ganesh, MD, MPH

Acid-base disorders are prevalent in critically ill patients, and a systematic approach is essential for evaluation. The first step is to determine the primary process based on a patient's pH, partial pressure of carbon dioxide, and bicarbonate measurements. After this is complete, the next step is to evaluate for respiratory or metabolic compensation. Deviations from expected compensation may indicate additional acid-base processes. For metabolic acidosis, anion gap calculation distinguishes between anion gap metabolic acidosis and non–anion gap metabolic acidosis. The evaluation for anion gap metabolic acidosis includes calculating the osmolal gap and conducting a gap-gap analysis. Evaluating non–anion gap metabolic acidosis involves urine anion gap calculation. These analyses identify potential etiologies and additional acid-base disturbances. Metabolic alkalosis assessment begins with measuring urine chloride levels to determine whether the process is a result of chloride depletion. Respiratory acidosis, caused by hypoventilation, often results from chronic lung disease or neuromuscular dysfunction. Respiratory alkalosis, due to hyperventilation, is common in sepsis, chronic liver disease, and acute pulmonary embolism.

Am Fam Physician. 2025;111(2):148-155. Copyright © 2025 American Academy of Family Physicians.

Acid-base disorders are common in patients who are critically ill.[1] A systematic approach to evaluating these disorders provides vital diagnostic information and guides timely treatment.[2-5] Acidosis leads to acidemia (pH less than 7.38)[6] and is typically due to one of three factors: (1) accumulation of acids (eg, salicylic acid, keto acids, lactic acid) or loss of alkali (as in diarrhea or proximal renal tubular acidosis); (2) decreased renal excretion of acid (as in kidney failure or distal renal tubular acidosis); or (3) accumulation of carbon dioxide in the body. Alkalosis is a process that leads to alkalemia (pH greater than 7.42) and is primarily caused by excessive carbon dioxide exhalation (respiratory alkalosis), the accumulation of alkali (sodium bicarbonate [HCO_3] administration), or loss of acid (as with gastrointestinal loss from vomiting and diarrhea).[7]

APPROACH

The physiologic approach to acid-base analysis is based on the concept of the carbonic acid-HCO_3 buffer system as a center of homeostatic control of blood pH.[2-4,8,9] In addition to assessment of vital signs and fluid status, blood gas measurement and basic chemistry panel are required. Venous blood gas often is measured initially instead of arterial blood gas because it is easier to obtain and may reveal metabolic changes earlier in cases of circulatory insufficiency.[10] An arterial blood gas measurement is preferred when assessing a patient's oxygenation status.

Primary Process

The first step is to determine serum pH level (normal serum pH is 7.38-7.42).[2] The next step is to identify the primary disturbance as metabolic or respiratory by comparing pH and arterial $Paco_2$) or estimated $Paco_2$ from venous blood ($Paco_2$ = $Pvco_2$ – 6 mm Hg)[11] with normal values (Table 1[2,5,6,11-14]).

If pH and $Paco_2$ levels are both decreased, the primary process is metabolic acidosis. If the pH level is decreased and the $Paco_2$ level is increased, it is respiratory acidosis. If the pH and $Paco_2$ levels are both increased, it is metabolic alkalosis. If the pH level is increased but $Paco_2$ level is decreased, it is respiratory alkalosis.[3,5] Figure 1 summarizes the initial evaluation of acid-base disorders.[2,5,15]

Compensation

The second step is to evaluate whether metabolic or respiratory compensation is appropriate using a specific formula to calculate expected $Paco_2$ compensation for metabolic disturbances

MASAHIRO J. MORIKAWA, MD, MPH, is the B. Lewis Barnett Jr Professor of Family Medicine at the University of Virginia, Charlottesville.

PRAKASH R. GANESH, MD, MPH, is an assistant professor in the Department of Family Medicine & Community Health at the University Hospitals Cleveland Medical Center, and at the Center for Community Health Integration, Case Western Reserve University School of Medicine, and Neighborhood Family Practice, Ohio

Author disclosure: No relevant financial relationships.

Address correspondence to Masahiro J. Morikawa, MD, MPH, at mm7jc@virginia.edu.

Downloaded from the American Family Physician website at www.aafp.org/afp. Copyright © 2025 American Academy of Family Physicians. For the private, noncommercial use of one individual user of the website. All other rights reserved. Contact copyrights@aafp.org for copyright questions and/or permission requests.

Descargado para Eric Mesia (ermesvid2812@valanides.com) en Valparaíso University de ClinicalKey.es por Elsevier en marzo 15, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

SHOUT
SHARE
IT

SORT: KEY RECOMMENDATIONS FOR PRACTICE

Clinical recommendation	Evidence rating	Comments
Using a systematic approach to evaluating acid-base disorders provides vital diagnostic information and guides timely treatment in critically ill patients.[2-5]	C	Reviews based on usual practice, consensus
To determine the primary process of an acid-base disorder, the pH and $Paco_2$ on blood gas should be evaluated, noting that abnormal values increasing or decreasing in the same direction indicate a metabolic process and those shifting in opposite directions indicate a respiratory process.[3,5]	C	Review based on usual practice, consensus
When evaluating acid-base disorders, expected patterns of $Paco_2$ compensation for metabolic disturbances and HCO_3 compensation for respiratory disturbances should be reviewed to determine if an additional acid-base disorder is present.[3,5]	C	Usual practice, consensus

HCO_3 = bicarbonate.

A = consistent, good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to https://www.aafp.org/afpsort.

TABLE 1

Normal Values for Acid-Base Analysis

Measurement	Normal value	Reference range
pH	7.4	7.38-7.42
$Paco_2$	40 mm Hg (5.32 kPa)	38-42 mm Hg (5.05-5.59 kPa)
$Pvco_2$	$Pvco_2 = Paco_2 + 6$ mm Hg	≤ 48 mm Hg (6.38 kPa)
HCO_3	24 mEq/L (24 mmol/L)	22-26 mEq/L (22-26 mmol/L)
Anion gap = Na – (Cl + HCO_3)	≤ 12 mEq/L (12 mmol/L)	8-14 mEq/L (8-14 mmol/L)
Calculated osmolarity = 2 x Na + glucose/18 + BUN/2.8	285 mOsm/kg (285 mmol/kg)	280-295 mOsm/L (280 mmol/kg)
Osmolal gap = measured – calculated osmolality	< 10 mOsm/L (10 mmol/kg)	10 ± 6 mOsm/L (10 ± 6 mmol/kg)
Urine anion gap = urine Na + urine K – urine Cl	< 0 mEq/L (0 mmol/L)	0 ± 10 mEq/L (0 ± 10 mmol/L)

BUN = serum urea nitrogen; Cl = chloride; HCO_3 = bicarbonate; K = potassium; Na = sodium.

Information from references 2, 5, 6, and 11-14.

or expected HCO_3 compensation for respiratory disturbances (Table 2[3,5]). If measured values deviate significantly from calculated expected values, a mixed acid-base disturbance is present (eg, an uncompensated acidosis or alkalosis, or a second acid-base disturbance).[3,5]

It is important to note that critically ill patients often present with, or develop, mixed acid-base disturbances, particularly when serum HCO_3 and $Paco_2$ levels deviate in opposite directions from their normal values.[4] In complex cases or when treatment does not yield expected improvements, consultation with an intensive care specialist or nephrologist is advisable.

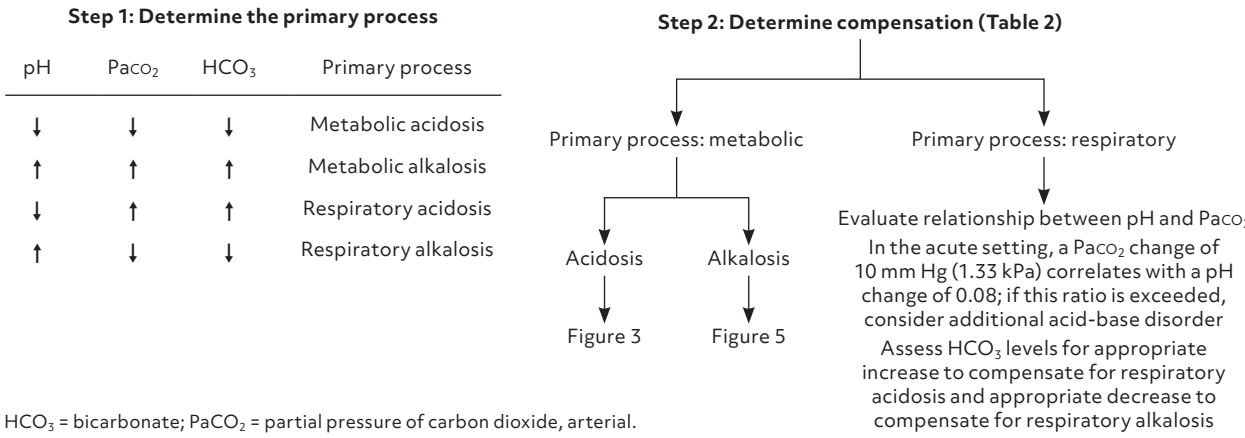
CASE 1

A 48-year-old patient with type 2 diabetes is admitted for acute confusion and diarrhea. The patient is afebrile and normotensive. Laboratory results are as follows:

- Arterial blood gas: pH = 7.30, $Paco_2$ = 25 mm Hg (3.33 kPa), Pao_2 = 85 mm Hg (11.30 kPa) on room air

Descargado para Eric Mesía (ermesvid2812@valanides.com) en Valparaiso University de ClinicalKey.es por Elsevier en marzo 15, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

FIGURE 1


Step 1: Determine the primary process
pH
Paco2
HCO3
Primary process
↓ ↓ ↓ Metabolic acidosis
↑ ↑ ↑ Metabolic alkalosis
↓ ↑ ↑ Respiratory acidosis
↑ ↓ ↓ Respiratory alkalosis
Step 2: Determine compensation (Table 2)
Primary process: metabolic
Primary process: respiratory
Acidosis
Alkalosis
Figure 3
Figure 5
Evaluate relationship between pH and Paco2
In the acute setting, a Paco2 change of 10 mm Hg (1.33 kPa) correlates with a pH change of 0.08; if this ratio is exceeded, consider additional acid-base disorder
Assess HCO3 levels for appropriate increase to compensate for respiratory acidosis and appropriate decrease to compensate for respiratory alkalosis

HCO_3 = bicarbonate; $PaCO_2$ = partial pressure of carbon dioxide, arterial.

Initial evaluation of acid-base disorders. Step 1 is to determine the primary process. After the primary process is identified, step 2 is to examine whether compensation is appropriate. If not, an additional acid-base process exists. Then, algorithms for individual acid-base disorders should be followed.

Information from references 2, 5, and 15.

- Serum: sodium = 148 mEq/L (148 mmol/L), potassium = 3.2 mEq/L (3.2 mmol/L), chloride = 104 mEq/L (104 mmol/L), HCO_3 = 10 mEq/L (10 mmol/L), urea nitrogen = 35 mg/dL (12.49 mmol/L), creatinine = 1.8 mg/dL (159.12 µmol/L), glucose = 360 mg/dL (19.98 mmol/L), osmolality = 330 mOsm/kg (330 mmol/L)

Comparison of the pH and $Paco_2$ indicates that the primary process is metabolic acidosis. Figure 2 summarizes the analysis of this case.[12-14,16,17]

METABOLIC ACIDOSIS

The patient in Case 1 demonstrates metabolic acidosis, which is classified as anion gap metabolic acidosis or non–anion gap metabolic acidosis by comparing sodium, chloride, and HCO_3.[4,12] (See https://www.mdcalc.com/calc/1669/anion-gap.)

Anion Gap Metabolic Acidosis

The first step in analyzing metabolic acidosis is calculating the anion gap[12,13] (Figure 3[2-5,18]). Anion gap metabolic acidosis is indicated by an elevated anion gap (greater than 12 mEq/L [12 mmol/L]). The etiologies of anion gap metabolic acidosis can be remembered using the mnemonic CATMUDPILES[19] (Table 3[3,5,12,19,20]). For anion gap metabolic acidosis, calculating the osmolal gap (measured – calculated osmolality; https://www.mdcalc.com/calc/91/serum-osmolality-osmolarity) can help differentiate between exogenous (high osmolal gap) and endogenous (normal osmolal gap) etiologies.[14] Common endogenous causes include lactic acidosis (from sepsis, shock or hypoperfusion of organs, or hypoxia), ketoacidosis (from uncontrolled diabetes or severe malnutrition), and uremia or kidney failure. Exogenous etiologies can be remembered using the mnemonic MADGAS[20] (Table 3[3,5,12,19,20]).

Non–Anion Gap Metabolic Acidosis

Non–anion gap metabolic acidosis is diagnosed if the anion gap is not elevated. Etiologies can be remembered using the mnemonic HARDUP[12] (Table 3[3,5,12,19,20]). Non–anion gap metabolic acidosis can result from kidney or gastrointestinal etiologies or infusion of large volumes of intravenous fluids

TABLE 2

Compensation Rules

Primary acid-base disorder	Expected compensation
Metabolic acidosis	$Paco_2 = HCO_3 + 15$
Metabolic alkalosis	$Paco_2 = 40 + [0.7 \times (HCO_3 - 24)]$
Respiratory acidosis	$HCO_3 = 24 + [1 \times (Paco_2 - 40)/10]$ (acute) $HCO_3 = 24 + [3.5 \times (Paco_2 - 40)/10]$ (chronic)
Respiratory alkalosis	$HCO_3 = 24 - [2 \times (40 - Paco_2)/10]$ (acute) $HCO_3 = 24 - [5 \times (40 - Paco_2)/10]$ (chronic)

HCO_3 = bicarbonate.

Information from references 3 and 5.

Descargado para Eric Mesía (ermesvid2812@valanides.com) en Valparaiso University de ClinicalKey.es por Elsevier en marzo 15, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

containing chloride (eg, normal saline) during resuscitation of critically ill patients.[21-24]

If the cause of non–anion gap metabolic acidosis is unclear, then calculating the urine anion gap helps differentiate between renal and nonrenal etiologies.[13,25] A normal urine anion gap indicates appropriate renal ammonia excretion and a nonrenal underlying cause (eg, diarrhea, total parenteral nutrition, high-volume intravenous fluids containing chloride). An abnormal urine anion gap suggests impaired renal ammonia excretion, such as in renal tubular acidosis.[26-28]

Further analysis of renal tubular acidosis is complicated, and consultation with an intensive care specialist or nephrologist may be beneficial. In general, treatment of renal tubular acidosis relies on reversal of the underlying kidney disease (eg, antibiotic use for kidney infection, improvement of renal perfusion from shock or sepsis, or removal of offending drugs or toxins).[11]

Gap-Gap Analysis

The gap-gap (Δ-Δ) analysis is the final step in metabolic acidosis assessment. A significant difference (exceeding 6 mEq/L) between the change in serum HCO_3 (ΔHCO_3 = 24 – measured HCO_3) and change in anion gap (ΔAG = calculated anion gap – 12) suggests an additional acid-base disturbance, as is seen in an anion gap metabolic acidosis (eg, diabetic ketoacidosis) complicated by a metabolic alkalosis (eg, contraction alkalosis due to vomiting).[16,17,19] Treatment of metabolic acidosis with sodium HCO_3 did not improve outcomes in multiple recent studies and may have negative consequences, such as paradoxical intracellular acidosis, hypocalcemia, or hypernatremia.[3]

In Case 1, the patient demonstrated anion gap metabolic acidosis, likely due to diabetic ketoacidosis and acute kidney injury. Respiratory compensation was appropriate. However gap-gap analysis revealed metabolic alkalosis, likely due to several days of preceding diarrhea. Treatment focused on addressing the primary issues: intravenous hydration to correct fluid deficits and reinitiation of insulin to manage diabetic ketoacidosis. With these interventions, the patient's acid-base status, kidney function, and mental status improved rapidly.

CASE 2

A 56-year-old patient with a history of hypertension and chronic obstructive pulmonary disease was admitted from the emergency department with a 1-week history of nausea, vomiting, and diarrhea. On examination, the patient was afebrile, blood pressure was 98/65 mm Hg, heart rate was 118 beats per minute, and respiratory rate was 28 breaths per minute. Laboratory results were as follows:

- Arterial blood gas: pH = 7.52, $Paco_2$ = 45 mm Hg (5.99 kPa), Pao_2 = 82 mm Hg (10.91 kPa) on room air
- Serum: sodium = 145 mEq/L (145 mmol/L), potassium = 3.2 mEq/L, chloride = 98 mEq/L (98 mmol/L), HCO_3 = 38 mEq/L (38 mmol/L), urea nitrogen = 15 mg/dL (5.35 mmol/L), creatinine = 1.2 mg/dL (106.08 µmol/L), glucose = 185 mg/dL (10.27 mmol/L)

FIGURE 2

Case 1

↓

Arterial blood gas: pH = 7.30, $Paco_2$ = 25 mm Hg (3.33 kPa), Pao_2 = 85 mm Hg (11.30 kPa) on room air

Serum: Na = 148 mEq/L (148 mmol/L), K = 3.2 mEq/L (3.2 mmol/L), Cl = 104 mEq/L (104 mmol/L), HCO_3 = 10 mEq/L (10 mmol/L), BUN = 35 mg/dL (12.49 mmol/L), creatinine = 1.8 mg/dL (159.12 µmol/L), glucose = 360 mg/dL (19.98 mmol/L), osmolality = 330 mOsm/kg (330 mmol/kg)

↓

Determine primary process (Figure 1)

pH ↓ and $Paco_2$ ↓, primary metabolic acidosis

↓

Evaluate for compensation (Table 2)

Estimated $Paco_2$ = HCO_3 + 15

10 + 15 = 25

Patient's $PaCO_2$ of 25 matches the calculated value of 25, indicating appropriate respiratory compensation

↓

Follow Figure 3 for metabolic acidosis

↓

Evaluate for anion gap = Na – (Cl + HCO_3)

148 – (104 + 10) = 34, which is elevated

Evaluate for etiology with the mnemonic CATMUDPILES (Table 3)

Keto acids are the likely cause in this case

↓

Evaluate for osmolal gap (Table 1)

Calculated serum osmolality = 2 x Na + glucose/18 + BUN/2.8

2 × 148 + 360/18 + 35/2.8 = 328.5

When compared with measured osmolality (330) the gap (measured [330] – calculated [328.5]) is < 10, suggesting an endogenous etiology for the acidosis

↓

Gap-gap analysis

Change in anion gap = 34 – 12 = 22

Change in HCO_3 = 24 – 10 = 14

Anion gap > HCO_3 suggests additional metabolic alkalosis, likely secondary to the patient's diarrhea in this case

↓

Conclusion of Case 1: Primary anion gap metabolic acidosis (endogenous) and metabolic alkalosis

BUN = serum urea nitrogen; Cl = chloride; HCO_3 = bicarbonate; K = potassium; Na = sodium.

Case 1. Start with Figure 1 to determine the primary process (metabolic acidosis), then evaluate for compensation by referring to Table 2. Since this is a metabolic acidosis, follow the algorithm in Figure 3 to complete the analysis.

Information from references 12-14, 16, and 17.

Descargado para Eric Mesía (ermesvid2812@valanides.com) en Valparaiso University de ClinicalKey.es por Elsevier en marzo 15, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

• Spot urine chloride less than 10 mEq/L (10 mmol/L)

Comparison of the pH and $Paco_2$ indicates that the primary process is metabolic alkalosis. Figure 4 summarizes the analysis for this case.[29,30]

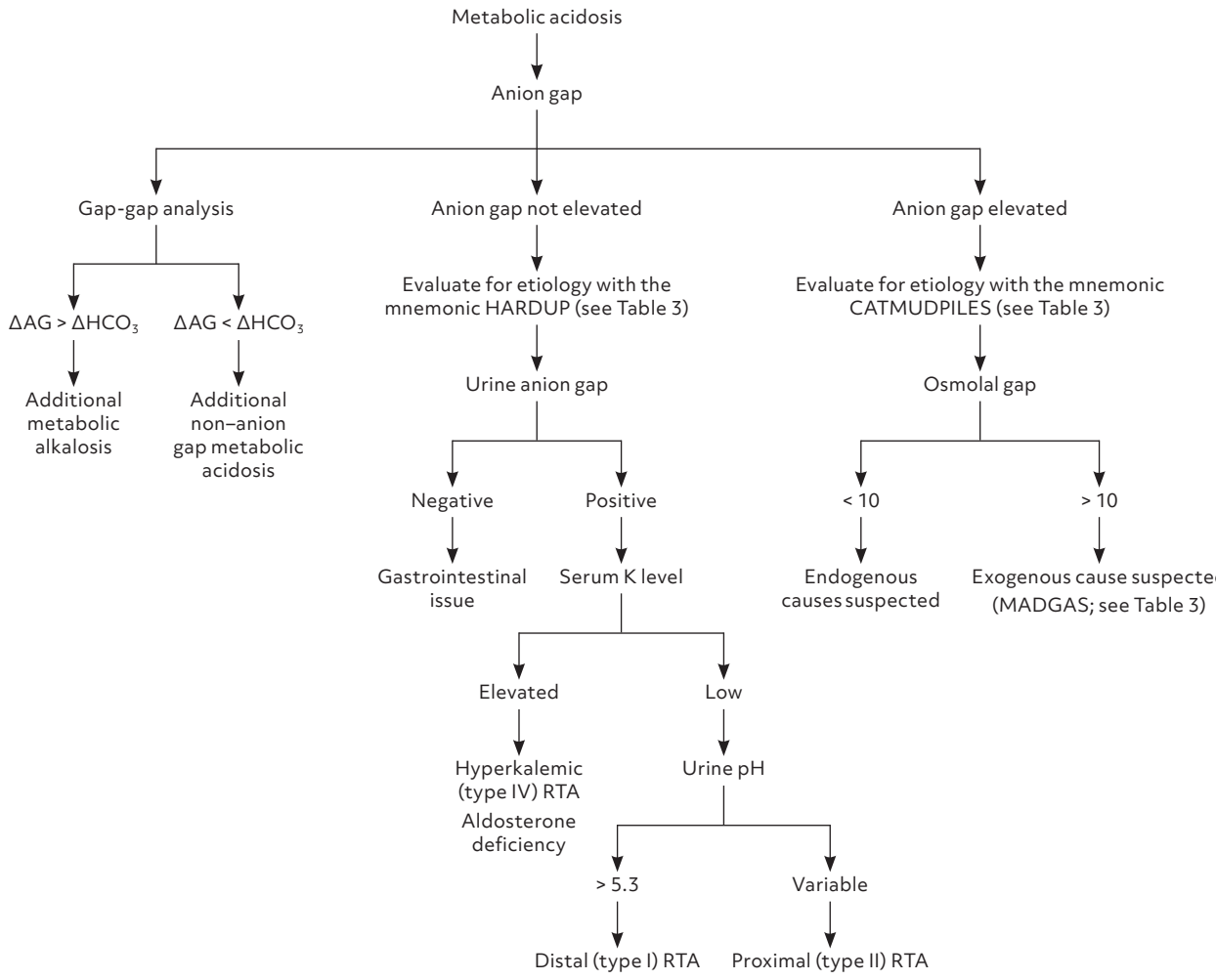
METABOLIC ALKALOSIS

Metabolic alkalosis is classified as chloride depletion or non–chloride depletion metabolic alkalosis.[29,30] Chloride depletion alkalosis, often due to vomiting, diarrhea, or chronic diuretic use, is characterized by low urine chloride levels (20 mEq/L [20 mmol/L] or less) and typically improves with saline infusion.

For non–chloride depletion alkalosis (urine chloride level greater than 20 mEq/L), the next step is to evaluate volume status and blood pressure.[11,18] Elevated blood pressure and volume status suggest hypermineralocorticoidism, warranting serum renin and aldosterone testing to guide further evaluation[31,32] (Figure 5[18,29,30,32]). Normal volume status and blood pressure may indicate primary kidney disorders such as Bartter syndrome or Gitelman syndrome.[32] Fluctuating levels can be due to diuretic use, often needed in the care of critically ill patients with volume overload, or fluid resuscitation.[11,18,30,32]

Metabolic alkalosis can also occur when overcompensating for an initial respiratory acidosis, particularly in patients with

FIGURE 3



AG = anion gap; HCO_3 = bicarbonate; K = potassium; RTA = renal tubular acidosis.

Metabolic acidosis. The evaluation starts with calculating anion gap and, if needed, osmolal gap. For patients with a primary metabolic acidosis, a gap-gap analysis can help determine if an additional acid-base disturbance exists. If the anion gap is not elevated, the urine anion gap is calculated to differentiate etiologies. Serum potassium level and urine pH help differentiate various types of renal tubular acidosis.

Information from references 2-5 and 18.

Descargado para Eric Mesía (ermesvid2812@valanides.com) en Valparaiso University de ClinicalKey.es por Elsevier en marzo 15, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

chronic obstructive lung disease with chronic hypercapnia. Such patients compensate for the respiratory acidosis by gradually increasing their HCO_3 level. Overzealous respiratory correction through mechanical ventilation (eg, bilevel positive airway pressure) can lead to a rapid decrease in $Paco_2$ whereas HCO_3 levels decrease gradually, resulting in metabolic alkalosis.[15,32]

Case 2 showed primary chloride depletion metabolic alkalosis due to gastrointestinal loss of chloride with persistent vomiting and diarrhea. Metabolic alkalosis resolved the next day after intravenous hydration was initiated. Respiratory alkalosis also resolved as the patient's volume depletion resolved.

RESPIRATORY ACIDOSIS AND ALKALOSIS

Respiratory acidosis results from hypoventilation, leading to increased $Paco_2$. The most common cause is chronic lung disease. An increasingly encountered cause is permissive hypercapnia, used in the treatment of acute lung injury or acute respiratory distress syndrome. Respiratory alkalosis results from hyperventilation, often seen in critically ill patients with sepsis, chronic liver disease, or inadequate sedation or pain control.[15]

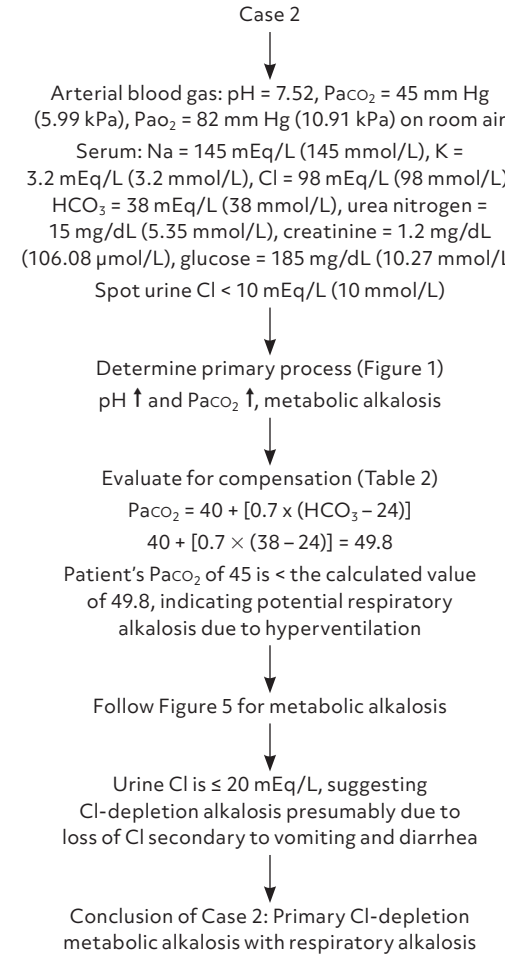
TABLE 3

Mnemonics for Acidosis Causes

Acid-base conditions	Mnemonic	Causes
Anion gap metabolic acidosis	CATMUDPILES	Carbon monoxide Alcohol, alcoholic ketoacidosis Toluene (glue sniffing) Methanol Uremia Diabetic ketoacidosis Paraldehyde, Isoniazid, iron, isopropyl alcohol Lactic acidosis Ethylene glycol (antifreeze) Salicylates
Exogenous high osmolal gap	MADGAS	Mannitol Alcohols Diatrizoate (imaging contrast) Glycerol Acetone Sorbitol
Non–anion gap metabolic acidosis	HARDUP	Hyperalimentation Adrenal insufficiency, acetazolamide Renal tubular acidosis Diarrhea and diuretics Ureteroenteric fistula Pancreaticoenteric fistula

Information from references 3, 5, 12, 19, and 20.

FIGURE 4


Case 2
Arterial blood gas: pH = 7.52, Paco2 = 45 mm Hg (5.99 kPa), Pao2 = 82 mm Hg (10.91 kPa) on room air
Serum: Na = 145 mEq/L (145 mmol/L), K = 3.2 mEq/L (3.2 mmol/L), Cl = 98 mEq/L (98 mmol/L), HCO3 = 38 mEq/L (38 mmol/L), urea nitrogen = 15 mg/dL (5.35 mmol/L), creatinine = 1.2 mg/dL (106.08 µmol/L), glucose = 185 mg/dL (10.27 mmol/L)
Spot urine Cl < 10 mEq/L (10 mmol/L)
Determine primary process (Figure 1)
pH ↑ and Paco2 ↑, metabolic alkalosis
Evaluate for compensation (Table 2)
Paco2 = 40 + [0.7 x (HCO3 – 24)]
40 + [0.7 × (38 – 24)] = 49.8
Patient's Paco2 of 45 is < the calculated value of 49.8, indicating potential respiratory alkalosis due to hyperventilation
Follow Figure 5 for metabolic alkalosis
Urine Cl is ≤ 20 mEq/L, suggesting Cl-depletion alkalosis presumably due to loss of Cl secondary to vomiting and diarrhea
Conclusion of Case 2: Primary Cl-depletion metabolic alkalosis with respiratory alkalosis

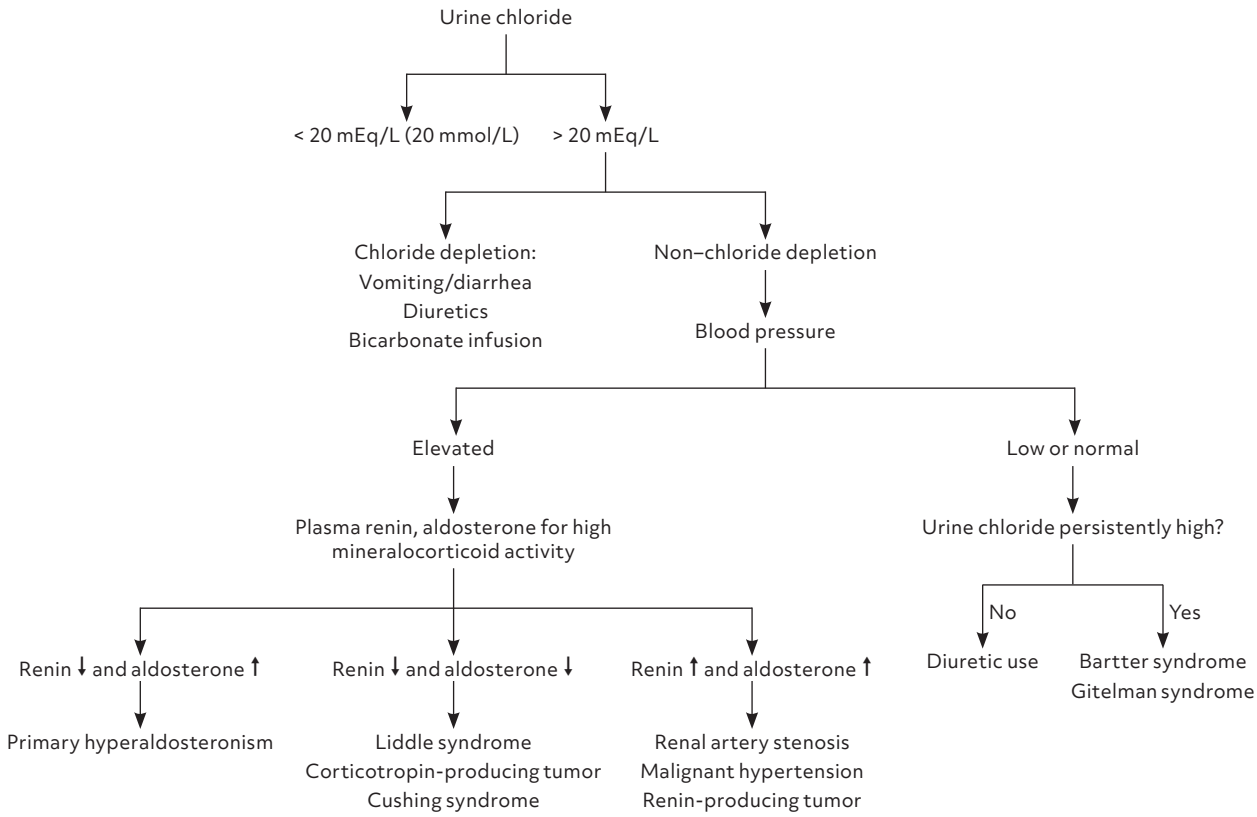
Cl = chloride; HCO_3 = bicarbonate; K = potassium; Na = sodium.

Case 2. Start with Figure 1 to determine the primary process, then evaluate for compensation by referring to Table 2. Since this is a metabolic alkalosis, follow the algorithm in Figure 5 to complete the analysis.

Information from references 29 and 30.

Descargado para Eric Mesía (ermesvid2812@valanides.com) en Valparaiso University de ClinicalKey.es por Elsevier en marzo 15, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

FIGURE 5



Metabolic alkalosis. Urine chloride measurement is useful to determine if metabolic alkalosis is a chloride depletion alkalosis or non–chloride depletion alkalosis. If non–chloride depletion, volume status and blood pressure should be examined. Renin and aldosterone levels can help differentiate between etiologies in non–chloride depletion alkalosis associated with elevated blood pressure.

Information from references 18, 29, 30, and 32.

If the primary process is respiratory, the patient should be quickly evaluated for additional acid-base disorders. In acute settings, this is estimated by checking the pH change associated with $Paco_2$ change: a 10-mm Hg change of $Paco_2$ typically correlates with a 0.08 change in pH (Δ0.08 pH correlates to Δ10 mm Hg $Paco_2$).[15] If the pH change exceeds this ratio, additional metabolic derangement should be suspected and investigated using the metabolic acidosis or alkalosis algorithms. Additional metabolic derangement should also be considered when the compensation in HCO_3 is greater than or less than expected for an acute or chronic respiratory process[2] (Table 2[3,5]).

Data Sources: We conducted a PubMed search using the key terms acid-base disorders, anion gap, and blood gas analysis and including randomized controlled trials, clinical trials, reviews, and some case series. We focused on clinically relevant articles, and we expanded our search for recommendations and guidelines, including DynaMed, Cochrane, and ACCESS. We found only a limited number of articles came up under our search that were clinically relevant. Search dates: December 20, 2023, and November 21, 2024.

REFERENCES

1. Djamali A, Singh T, Melamed ML, et al. Metabolic acidosis 1 year following kidney transplantation and subsequent cardiovascular events and mortality: an observational cohort study. *Am J Kidney Dis*. 2019;73(4):476-485.
2. Berend K, de Vries APJ, Gans ROB. Physiological approach to assessment of acid-base disturbances. *N Engl J Med*. 2014;371(15):1434-1445.
3. Achanti A, Szerlip HM. Acid-base disorders in the critically ill patient. *Clin J Am Soc Nephrol*. 2023;18(1):102-112.
4. Whittier WL, Rutecki GW. Primer on clinical acid-base problem solving. *Dis Mon*. 2004;50(3):122-162.
5. Palmer BF. Approach to fluid and electrolyte disorders and acid-base problems. *Prim Care*. 2008;35(2):195-213.
6. Berend K. Acid-base pathophysiology after 130 years: confusing, irrational and controversial. *J Nephrol*. 2013;26(2):254-265.

Descargado para Eric Mesía (ermesvid2812@valanides.com) en Valparaiso University de ClinicalKey.es por Elsevier en marzo 15, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

7. Hamm LL, Nakhoul N, Hering-Smith KS. Acid-base homeostasis. *Clin J Am Soc Nephrol*. 2015;10(12):2232-2242.
8. Gomez H, Kellum JA. Understanding acid base disorders. *Crit Care Clin*. 2015;31(4):849-860.
9. Haber RJ. A practical approach to acid-base disorders. *West J Med*. 1991;155(2):146-151.
10. Gauthier PM, Szerlip HM. Metabolic acidosis in the intensive care unit. *Crit Care Clin*. 2002;18(2):289-308.
11. Kamel KS, Halperin ML. *Fluid, Electrolyte, and Acid-Base Physiology*. 5th ed. Elsevier; 2016.
12. Casaletto JJ. Differential diagnosis of metabolic acidosis. *Emerg Med Clin North Am*. 2005;23(3):771-787.
13. Kraut JA, Madias NE. Serum anion gap: its uses and limitations in clinical medicine. *Clin J Am Soc Nephrol*. 2007;2(1):162-174.
14. Chabali R. Diagnostic use of anion and osmolal gaps in pediatric emergency medicine. *Pediatr Emerg Care*. 1997;13(3):204-210.
15. Martin L. Primary and mixed acid-base disorders. *All You Really Need to Know to Interpret Arterial Blood Gases*. 2nd ed. Lippincott Williams & Wilkins; 1999:137.
16. Rastegar A. Use of the DeltaAG/DeltaHCO_3– ratio in the diagnosis of mixed acid-base disorders. *J Am Soc Nephrol*. 2007;18(9):2429-2431.
17. Paulson WD, Gadallah MF. Diagnosis of mixed acid-base disorders in diabetic ketoacidosis. *Am J Med Sci*. 1993;306(5):295-300.
18. Gennari FJ. Pathophysiology of metabolic alkalosis: a new classification based on the centrality of stimulated collecting duct ion transport. *Am J Kidney Dis*. 2011;58(4):626-636.
19. Reddy P, Mooradian AD. Clinical utility of anion gap in deciphering acid-base disorders. *Int J Clin Pract*. 2009;63(10):1516-1525.
20. Judge BS. Differentiating the causes of metabolic acidosis in the poisoned patient. *Clin Lab Med*. 2006;26(1):31-48.
21. Kraut JA, Madias NE. Differential diagnosis of nongap metabolic acidosis: value of a systematic approach. *Clin J Am Soc Nephrol*. 2012; 7(4):671-679.
22. Yunos NM, Kim IB, Bellomo R, et al. The biochemical effects of restricting chloride-rich fluids in intensive care. *Crit Care Med*. 2011; 39(11):2419-2424.
23. Schreiber MA. The use of normal saline for resuscitation in trauma. *J Trauma*. 2011;70(5 suppl):S13-S14.
24. Lafrance JP, Leblanc M. Metabolic, electrolytes, and nutritional concerns in critical illness. *Crit Care Clin*. 2005;21(2):305-327.
25. Rodríguez Soriano J. Renal tubular acidosis: the clinical entity. *J Am Soc Nephrol*. 2002;13(8):2160-2170.
26. Soleimani M, Rastegar A. Pathophysiology of renal tubular acidosis: core curriculum 2016. *Am J Kidney Dis*. 2016;68(3):488-498.
27. Giglio S, Montini G, Trepiccione F, et al. Distal renal tubular acidosis: a systematic approach from diagnosis to treatment. *J Nephrol*. 2021; 34(6):2073-2083.
28. Batlle DC, Hizon M, Cohen E, et al. The use of the urinary anion gap in the diagnosis of hyperchloremic metabolic acidosis. *N Engl J Med*. 1988;318(10):594-599.
29. Luke RG, Galla JH. It is chloride depletion alkalosis, not contraction alkalosis. *J Am Soc Nephrol*. 2012;23(2):204-207.
30. Emmett M. Metabolic alkalosis. A brief pathophysiologic review. *Clin J Am Soc Nephrol*. 2020;15(12):1848-1856.
31. Fernandes A, Falcão L, Raimundo M. A severe case of hypokalemic metabolic alkalosis: a quiz. *Am J Kidney Dis*. 2023;81(4):A13-A16.
32. Do C, Vasquez PC, Soleimani M. Metabolic alkalosis pathogenesis, diagnosis, and treatment: core curriculum 2022. *Am J Kidney Dis*. 2022;80(4):536-551.

Descargado para Eric Mesía (ermesvid2812@valanides.com) en Valparaiso University de ClinicalKey.es por Elsevier en marzo 15, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.